Edison Group, Inc

Optimizing Virtualized Datacenters

Comparing the Scalability of Intel® Xeon® Processor-based Server Platforms for VMware-based Consolidation Solutions

For

Intel

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Introduction

Purpose of the Study

Edison Group undertook the study described in this report to assess the scalability of Intel®-based 2-way and 4-way server platforms in typical applications in consolidated server environments. In the absence of any industry-standard virtualization capacity benchmarks, this study provides the reader with a guide to the performance differences between Intel® Xeon® 2-way and 4-way servers using their entry-level and high-end processor options for virtualized solutions. The results are presented in this report.

Who Should Read This Report

This report should assist IT professionals in deploying or developing a strategy for consolidated and virtualized enterprise servers. The results of this study should help readers decide which virtualized platform best meets their needs by providing data on performance and power scalability between the most popular Intel®-based server types and processors.

Executive Summary

Intel's top-end dual core based 2-way and 4-way platforms provide significant increases in the ability to run VM workloads. 2-way platforms can support 87 percent and 4-ways up to 140 percent more VM workloads than the entry, single core configurations. In addition the top-end dual core based platforms deliver significantly better power utilization, 23 percent on 2-way and 68 percent on 4-way's. In addition, the top-end MP platforms surprisingly proved to be the most power-efficient platform overall. The top-end dual core platforms also provide significantly more headroom - additional computing capacity, to manage workload spikes. End users deploying virtualization will find the optimal power efficiency, highest platform densities and best support for dynamic computing workloads using the top-end dual-core based platforms.

Contents of This Report

The contents of this report are as follows:

- *Goal of This Study* — Explains the trends in computing behind the reason that the study was conducted.
- *Approach* — Discusses the rationale behind the methodology used in the study.
- *Testbed Configuration* — Describes the hardware and software used in the testing for the study.

- ***Methodology*** — Describes the methodology used in running the tests.
- ***Tests Results*** — Presents the high-level summary results of the testing.
- ***DP Versus MP Platform Considerations*** — References the test results in discussing the difference between Dual Processor and Multiple Processor platforms such as scalability and RAS features, and considerations in choosing one platform over another.
- ***Analysis and Conclusions*** — Provides interpretive conclusions based on research and issues discussed in the body of the report.

Goal of This Study

Improvements in distributed computing technology — particular in operating system design — have made it feasible today to operate multiple server applications as "virtual machines" (VMs) within a single physical platform using Intel® X86 processors. No longer is it necessary to have a server entirely dedicated to e-mail, for example, or a web server, or any shared database or database application.

Server consolidation is not only feasible but is frequently highly desirable. Reducing 100 physical servers to 50, for example, has obvious factors to recommend it in terms of space, maintenance, licensing, etc. Consolidating servers can also reduce the wasteful processing inefficiency of dedicated servers, which commonly operate at well under 20 percent processor utilization.

In light of this and the trend favoring server consolidation, Edison Group set out to measure the effect that higher-performance Intel® 2-way and 4-way servers would have on VM capacity, testing the premise that better platforms and higher-end[1] processors will result in greater consolidation capacity. Specifically, tests would be designed to determine the ratio of processing cost to performance strictly in terms of capacity to reduce overall server hardware — for example, if a 20 percent higher-priced processor might yield 60 percent more VM capacity. ROI and TCO factors — while certainly cost considerations for a real-life IT department — are not covered in this study

Therefore, this study strictly helps provide relative VM capacity for the different platforms and/or CPUs in a virtualized environment, without considering other valid platform decision criteria beyond capacity. Edison Group is currently developing a follow-on study to address these other, factors. This paper will be available in April 2006 at http://www.theedison.com.

[1] Intel provides a series of CPUs with incremental performance advantages; this report applies the terms "entry-level" and "top-end" to refer to those with the lowest and highest overall performance capacity, respectively.

Approach

Edison Group wanted to compare the effect of virtual machine density on the highest-volume Intel®-based server platform types (2-way and 4-way), as well as entry-level versus top-end Intel® processors supported on each platform. The approach taken was to replicate the common solutions IT managers are reportedly deploying when they virtualize and consolidate, and then to test the impact on the capacity of targeted Intel®-based server platforms with different CPUs. The results provide an indicator of the capacity scaling between Intel®-based server platforms and — within the same platform — of the entry-level versus top-end processors.

Based upon vendor recommendations and the experience of our analysts as well as corporate end-users we'd interviewed, we determined that the following usage models were common in the field:

- Two virtual machines per processor core (a 2-way single-core server would have four VMs)
- CPU utilization levels of 60–65 percent (including the ESX Server overhead) as the target comfort levels for most users
- Use of VMware ESX virtualization software
- Use of mixed application (with no typical mix identified)
- We accepted these models as our basis for evaluation and developed a set of four virtual machines and the required load generators so that we could attain the target CPU utilization of 65 percent. We established our baseline workloads by tuning the applications in the virtual machines to reach that target utilization on the base dual-processor server running the entry-level 2.8 GHz Xeon® processors.

The virtual machines were designed to model standard modern business applications and processes, specifically:

- File sharing with Windows 2003 Server
- Database access with MS SQL Server 2000 running on Windows 2003 Server
- Messaging with MS Exchange 2003 running on Windows 2003 Server
- Static web transactions with IIS 6.0 running on Windows 2003 Server

Besides fairly representing the modern business environment, these applications differently stress the server resources, including network and disk-based utilization (file sharing), disk and CPU utilization (messaging), network and CPU utilization (web server), and CPU utilization (SQL). With this approach, the effect of 4-way multiple processors and the recently introduced dual-core processors can be studied in a diverse application environment.

The rest of our research was based on utilizing these virtual machines as interchangeable building blocks to compare the capabilities of servers running different processors. This means that the virtual machines, once configured for the baseline system, were not re-tuned for each subsequent platform.

Test Bed Configuration

In establishing the lab setup for the actual testing, the following assumptions were made and precautions observed:

- The virtual machines and the operating system were installed on different SCSI drives.
- The VMs were not bound to a particular processor.
- All the VMs were configured as a single-CPU VM for ease of comparison.
- All the VMs were given sufficient memory to prevent unnecessary swapping, which could negatively affect the performance.
- All the server memory in multiple-processor chipsets was spread evenly across all the memory banks to maximize the available bandwidth.

Hardware

Intel provides product families of 2-way and 4-way CPUs for its customers, providing a range of price and performance options. The chart below outlines the key differences between the entry-level and top-end CPUs in their class offered by Intel at the time of this writing.

NOTE: For the charts and graphs appearing in this report, we use the abbreviations DP for the 2-way (D)ual (P)rocessor systems and MP for the 4-way (M)ultiple (P)rocessor systems. We use the abbreviations SC for the entry-level (S)ingle (C)ore and DC for the top-end (D)ual (C)ore.

	Type	Speed	Cache Size(1)	# Cores
Entry-SC	2-way	2.8 GHz	2 MB	1
	4-way	3.16 GHz	1 MB	1
Top-DC	2-way	2.8 GHz	2 MB	2
	4-way	3.0 GHz	2 MB	2

(1) L2 cache size per core

For this testing, generic Intel®-based 2- and 4-way platforms were used. The 2-way utilized the Intel® SC2400JR2. Detailed information can be found at http://www.intel.com/design/servers/buildingblocks/2pplatforms.htm#Intel_Server_Platform_SR1400JR2

The 4-way platforms utilized the Intel® SR4850HW4. Detailed information can be found at http://www.intel.com/design/servers/platforms/sr4850HW4/

Based on the CPUs used in this testing, it is effectively a test of single- versus dual-core CPU technology; with the noted exceptions that the top-end Intel® SR4850HW4 / dual-core has larger L2 caches than the entry-level Intel® SR4850HW4 / single-core processor. The four configurations are defined in the table below.

	DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
# Processors Used	2	2	4	4
CPU Speed	2.8Ghz	2.8Ghz	3.16Ghz	3.0Ghz
CPU Cache Size	2MB	2MB	1MB	2MB
# Cores	1	2	1	2
FSB Speed	800 Mhz	800 Mhz	667 Mhz	800 MHz
Memory Size	4GB	4GB	8GB	8GB
Memory Type	DDR2 ECC	DDR2 ECC	DDR2 ECC	DDR2 ECC
Rack Size	2U	2U	4U	4U

NOTE: The only difference between the entry-level and top-end platform configurations used is the processor employed; the primary difference in configuration between the dual-processor and multiple-processor systems is the addition of 4 GB of memory, which is required to support the larger number of virtual machines as well as to provide optimal platform performance.

Software

The VMware software utilized throughout was ESX 2.5.2 build 16390.

The applications used in developing the virtual machine workload were chosen to represent a mix typical to a modern business environment, with the following virtual machines created:

- Microsoft Windows 2003 Server Operating System
- IIS 6.0
- MS SQL Server 2000
- MS Exchange

Loads for the virtual machines were generated as follows:

NetBench: Windows Server 2003 SP1 optimized as a file servers with the Linux-based public domain smbtorture utility that emulates the CIFS file sharing requests of a NetBench client farm. Smbtorture utility is a part of Samba 3.0.21a distribution.[2,3] The application was compiled and used as described in the documentation.

WebBench: Windows Server 2003 SP1 with IIS 6.0, serving static web pages with text and graphics. HP httperf utility[4] was used to generate multiple simultaneous HTTP GET requests similar to the load generated by a WebBench client farm. The application was compiled and used as described in the documentation.

[2] http://us3.samba.org/samba/
[3] http://www.sambaxp.org/uploads/media/sharpe-XP2003.pdf
[4] http://www.hpl.hp.com/research/linux/httperf/

SQL: Windows Server 2003 SP1 with Microsoft SQL Server 2000 SP4 and with the sample databases (pubs and Northwind). DTM DB Stress 1.02.18 from SQL Edit[5] was used as a SQL load generator using a number of simultaneously executed queries. The application was used in accordance with the vendor documentation.

Exchange: Windows 2003 SP1 with Exchange 2003 SP1, with a private and public mailbox store. LoadSim 2003 was used to emulate the common user messaging activity. The application was used in accordance with the supplied User Guide.

Besides fairly representing the modern business environment, these applications differently stress the server resources, starting from primarily network and disk-based utilization (file sharing) to disk and CPU utilization (messaging) to network and CPU utilization (web server) to primarily CPU utilization (SQL). Thus, the effect of introducing the dual-core CPU is studied in a diverse application environment.

The virtual machines were configured by configuring the parameters of the load generator to produce approximately 13-14 percent of the cumulative CPU load of the Entry - DP machine. The 30-minute runs were executed to ascertain that the sustained (rather than peak) loads were measured. These machines were then copied to other servers and replicated as needed to produce additional loads.

Methodology

Four platform configurations were devised: two 2-way and two 4-way. Two generic Intel®-based platforms were used in this study and are representative of platforms being offered by many of Intel's OEMs. The two platforms were populated with the maximum CPUs supported (this is typical for consolidated servers), with one configuration using entry-level, single-core CPUs and a second using top-end, dual-core processors.

A baseline system was developed: the 2-way platform with entry-level CPUs installed. Four VMware workloads were developed using the mix of applications representing a typical modern business mix of file sharing, database access, messaging, and web transaction tasks. The applications were then tuned to utilize approximately 60–65 percent of the CPU capacity with the workloads being generated on the base system.

The other three tested configurations were then set up with the identical 4-base workloads. Additional virtual machines/workloads were added until the platform reached its targeted CPU utilization of 60–65 percent. The servers were not "tuned" beyond defaults necessary for the system to accommodate the target number of VMs — that is, four VMs per processor running on the base server configuration, a 4 GB dual-processor box. No additional setting adjustments were made other than the setup of the

[5] http://www.sqledit.com/stress/index.html

VMs and the assigning of resources, so that subsequent tests would use the same settings on the servers.

Test Results

The test results are summarized in the table below:

	DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
# VMs	4	7	7	17
CPU Utilization	63%	59%	62%	62%

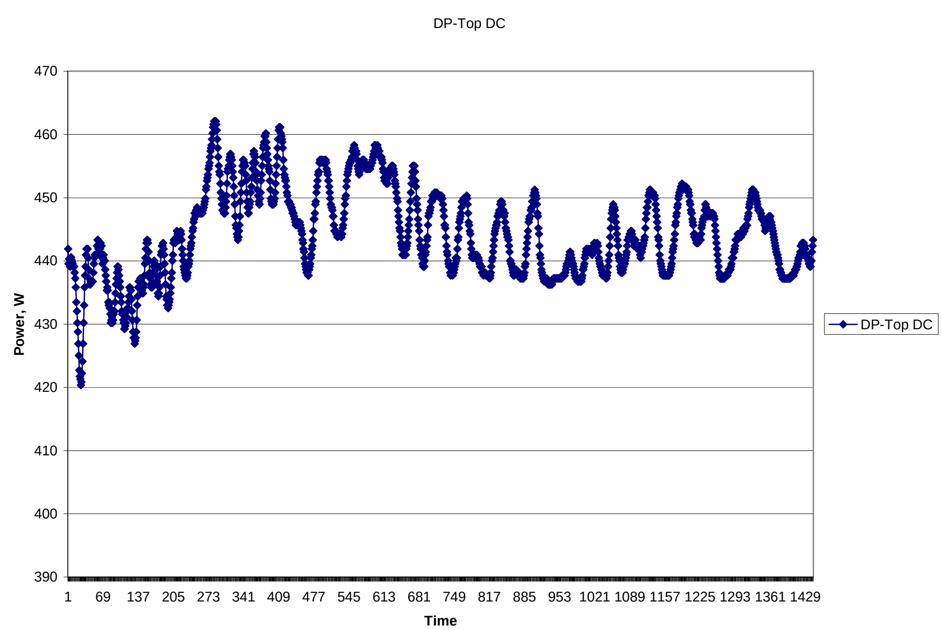
VMware provides a CPU monitoring utility within their Virtual Center product. We have provided screen captures of the CPU utilization for each of the configurations in the addendum.

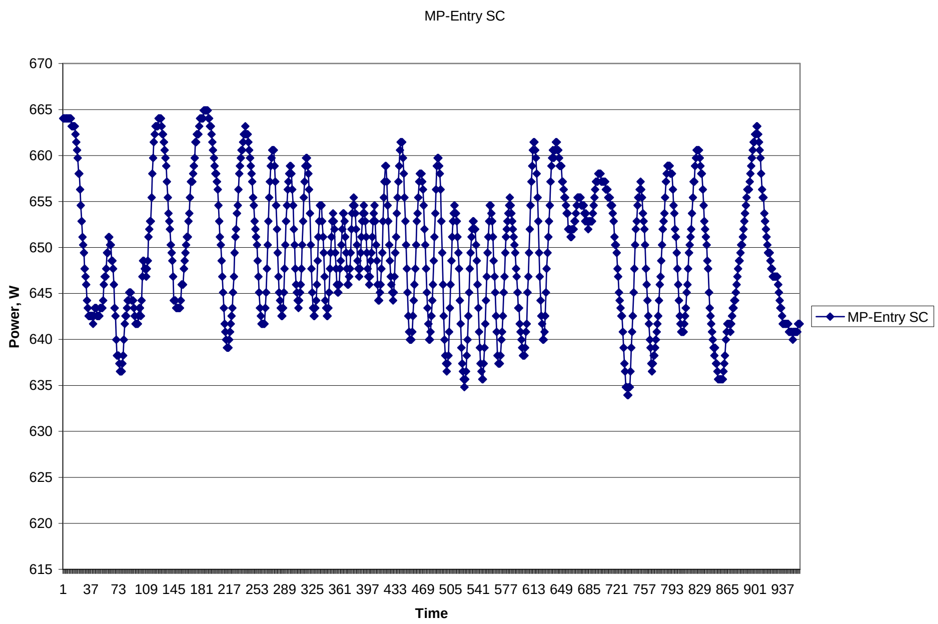
Power Consumption

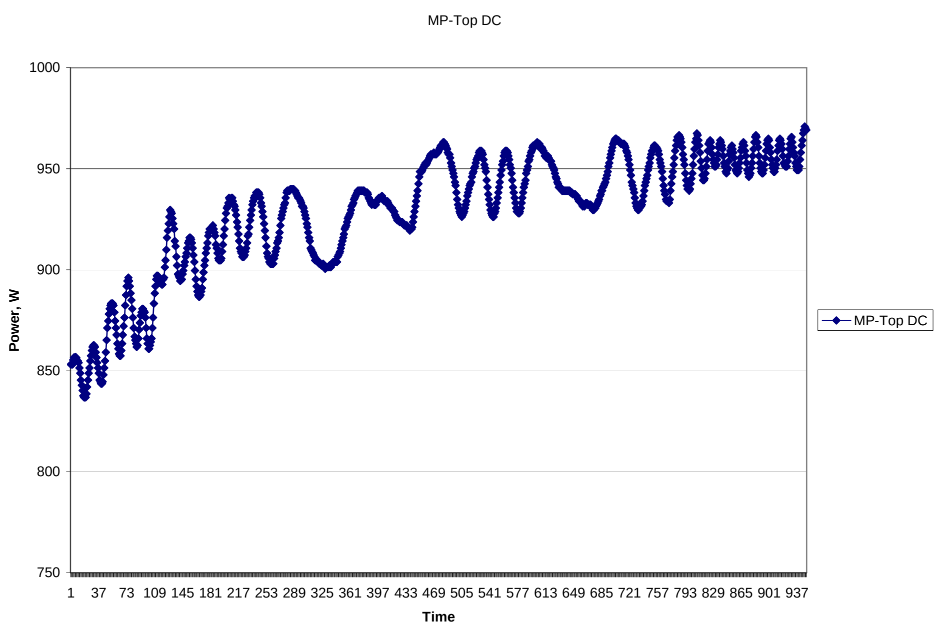
Average system power was measured during the benchmark execution using the Intel® Power Meter. It demonstrated that the electric power utilization was independent of both the number of the executed virtual machines and the total CPU load of the server. This is likely due to the high CPU utilization being driven by the workloads. The power data observed is provided in the table below.

	DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
Average Power (Watts)	291	441	650	929

Power utilization curves for Intel® SC2400JR2 (DP)-SC and Intel® SC2400JR2 (DP)-DC are also being provided. The power utilization curves were essentially the same for Intel® SR4850HW4 (MP)-Entry and Intel® SR4850HW4 (MP)-DC.




MP-Entry SC
670
665
660
655
650
645
640
635
630
625
620
615
Power, W
1 37 73 109 145 181 217 253 289 325 361 397 433 469 505 541 577 613 649 685 721 757 793 829 865 901 937
Time
MP-Entry SC


MP-Top DC
1000
950
900
850
800
750
Power, W
1 37 73 109 145 181 217 253 289 325 361 397 433 469 505 541 577 613 649 685 721 757 793 829 865 901 937
Time
MP-Top DC

MP Versus DP Platform Considerations

This study focuses on the performance scalability differences between Intel®-based 2-way and 4-way servers, as well as between their associated entry-level versus high-end processors. While performance is a key element in IT platforms and server consolidation decisions, it is not the only one and is usually not the primary criterion for choosing a server. IT managers must consider the ROI or TCO of a system, as well as the servers' ability to scale with increasing business requirements and meet reliability standards for running business-critical applications. MP platforms are typically more capable than DP in these areas, making them ideal for most server consolidation environments.

Reliability is increasingly important in consolidation environments. Because more applications are being executed on a single physical server, the failure of any one server would have a broader impact within the data center and user base.

Scalability is also important, so that the server can be upgraded not only with more processors but with more and/or faster I/O devices and memory rather than requiring the purchase of additional servers. The operational efficiencies of provisioning and managing less servers is a key consideration in many data centers, where licensing cost efficiencies between platforms are also typically taken into account. The physical space and power used by the servers, too, is often a factor in data centers with limited space or power/cooling. Every data center and IT group has unique computing environments and challenges, and their ultimate platforms decisions will vary accordingly.

We are providing a high-level comparison of the key differentiated features of the platforms used in this study for the reader to consider.

Feature	**2-Way**	**4-Way**
CPU Support	2 x Xeon® CPUs	4 x Xeon® MP CPUs
Memory Capacity	24 GB/6 DIMMs	64 GB/16 DIMMs
Memory Channels	2	4
PCI.x/e	3	7
Hard Drive Support	3-Hot Swap	10-Hot Swap SCSI

Reliability Features		ECC on L2 cache
		Hot Plug PCI
		Hot Plug Memory
		Memory RAID
		Memory Sparing
		Memory Mirroring

** Average power used by the system for the configuration used in this study entry-level / high-end CPU.

Many OEMs of Intel®-based servers also deliver SMP systems supporting from 8 to over 128 processors. These systems should be considered by IT managers looking for the highest level of consolidation on the lowest number of physical servers.

Analysis and Conclusions

	DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
Number of VMs Run	**4**	**7**	**7**	**17**
CPU Utilization	**63%**	**59%**	**62%**	**62%**
System Avg Power (Watts)	**291**	**441**	**650**	**929**
VM Capacity	**1.00**	**1.87**	**1.78**	**4.32**
VM Headroom Capacity	**0.59**	**1.10**	**1.04**	**2.54**
Watts per VM	**73**	**59**	**91**	**54**

VM capacity is a simple extrapolation of the number of VMs run adjusted for the differences in CPU utilization. Since the VM's granularity is high, the CPU adjustment provides for best overall relative metric to show scaling between platforms and CPUs used in this testing. This key metric will be utilized in the follow-on business analysis whitepaper.

End-user rationale for running the platforms up to 65 percent CPU utilization was to allocate the unused CPU headroom for reserves, in case applications temporarily required additional resources (a demand "spike"). VM headroom capacity is the amount

of capacity available within the platform that can be utilized for these spikes in the computing demand. If the computing environment does not require this headroom, then this capacity can be used to run additional VM workloads (by increasing platform CPU utilization).

The Watts per VM metric shows the amount of power used for the VMs run in this test and is calculated by dividing the VM capacity by the actual power measured by the platform during execution.

VM capacity of the top-end dual core systems were 87 percent–143 percent faster than single-core configurations. The 87 percent measured on the DP servers show the benefit of dual cores in the same platform and architecture (the only difference between the CPUs and platforms was doubling of cores). The 143 percent measured on the MP platforms is attributed to dual cores but also a faster FSB and doubling of L2 cache size. Platforms used in highly dynamic computing environments will benefit significantly from the use the top-end dual core platforms.

The VM capacity is summarized in the chart below:

	DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
# VMs	4	7	7	17
CPU Utilization	63%	59%	62%	62%

The overall power used per VM was significantly lower in the top-end, dual-core based platform; providing 23 percent–75 percent more power efficiency than the single core platforms. The MP TOP DC platform was also 7 percent more efficient than the DP TOP DC platform, due to its ability to run 2.4 times the VM capacity. Decision-makers looking to drive the overall lowest power utilization should utilize the top-end, dual-core based platforms, with the top-end MP systems providing the highest overall power efficiency.

The power consumption data is summarized in the chart below:

	DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
Average Power (Watts)	291	441	650	929

Addendum: Testing Details

This addendum to the *Optimizing Virtualized Data Centers* study conducted by Edison Group presents tables showing the results for each application/virtual machine combination on all four server platforms, plus a Hosts Summary table containing the cumulative results for all applications and virtual machines on each platform. The metrics for each virtual machine/platform combination include:

CPU Utilization — When configured on the baseline dual-processor machine, each VM was configured for a single virtual processor. Dual processor utilization was therefore approximately half that of the single virtual processor. In our tables, this is seen in the entry-level Intel® SR4850HW4 (DP-Entry SC) as a 30 percent CPU utilization that in actuality is 15 percent of the aggregate CPU utilization on the machine. Since the virtual machines were replicated as we increased their number, the same baseline process utilization is depicted, though the aggregate utilization was the denominator of the total number of processors or processor cores on the specific platform.

Disk Total, Kbytes/second — Disk transfers reported as measured in the VMware VirtualCenter.

Active Memory, Mbytes – This is the memory utilized by the VMs.

Network Throughput, Mbits/second — This is the utilization of the virtual network interfaces in VMware.

The Hosts Summary table represents the cumulative results reported by VMware ESX. It includes additional data for CPU utilization by VMware ESX. The utilization figures in this table are taken directly from the data provided by the VMware ESX and, being added up, total to the cumulative host resource utilization reported in the "Host Summary" section below.

NetBench

The following table presents the statistics for Windows Server 2003 file sharing.

		DP-Entry SC	*DP-Top DC*	*MP-Entry SC*	*MP-Top DC*
VMs	*Parameter*				
NetBench1	CPU, %	*26*	*37*	*35*	*29*
	Disk total, KBps	*850*	*1,300*	*1,100*	*1,000*
	Active memory, MB	*65*	*95*	*110*	*90*
	Network total, Mbps	*47*	*64*	*54*	*44*
NetBench2	CPU, %		*37*	*35*	*28*
	Disk total, KBps		*1,300*	*1,100*	*700*
	Active memory, MB		*95*	*110*	*80*
	Network total, Mbps		*61*	*51*	*40*

		DP-Entry SC	DP-Top DC	MP-Entry SC	MP-Top DC
NetBench3	CPU, %				*29*
	Disk total, KBps				*700*
	Active memory, MB				*85*
	Network total, Mbps				*40*
NetBench4	CPU, %				*29*
	Disk total, KBps				*1,250*
	Active memory, MB				*110*
	Network total, Mbps				*43*

Notes:

Load generation for this virtual machine was provided by smbtorture. The baseline load used in all VM instances was for three clients reading and writing a mixed set of files at a transfer rate set at 5 MB per minute. In this and all subsequent test application tables, the results are for a test run of approximately 30 minutes from the stabilization point.

Utilization across all parameters was very consistent, with network utilization showing the greatest variation between VMs, though there was some memory variation as well. The overall system resource utilization for file sharing is very low.

WebBench

The following table presents the statistics for HTTP.

		DP-Entry SC	DP-Top DC	MP-Entry DC	MP-Top DC
VMs	***Parameter***				
WebBench1	CPU, %	*26*	*29*	*34*	*29*
	Disk total, KBps	*24*	*22*	*24*	*25*
	Active memory, MB	*28*	*26*	*25*	*25*
	Network total, Mbps	*62*	*62*	*62*	*62*
WebBench2	CPU, %		*27*	*33*	*29*
	Disk total, KBps		*24*	*25*	*25*
	Active memory, MB		*27*	*25*	*25*
	Network total, Mbps		*62*	*62*	*62*
WebBench3	CPU, %				*29*
	Disk total, KBps				*25*
	Active memory, MB				*25*
	Network total, Mbps				*62*
WebBench4	CPU, %				*29*
	Disk total, KBps				*25*
	Active memory, MB				*25*
	Network total, Mbps				*62*

Notes:

Load generation for this virtual machine was provided by HP httperf utility similar to the load generated by a WebBench client farm. A single client generated 200 requests per second. The pages requested included a single web page containing a long (approximately 20 page) text document and a web page containing a large graphic. The utilization is very consistent across parameters.

Exchange

The following table presents the statistics from the Microsoft Exchange virtual machines.

		DP-Entry SC	*DP-Top DC*	*MP-Entry SC*	*MP-Top DC*
VMs	*Parameter*				
Exchange1	CPU, %	*27*	*23*	*36*	*22*
	Disk total, KBps	*600*	*550*	*800*	*500*
	Active memory, MB	*290*	*325*	*390*	*350*
	Network total, Mbps	*0*	*0*	*0*	*0*
Exchange2	CPU, %				*22*
	Disk total, KBps				*500*
	Active memory, MB				*350*
	Network total, Mbps				*0*
Exchange3	CPU, %				*22*
	Disk total, KBps				*500*
	Active memory, MB				*350*
	Network total, Mbps				*0*
Exchange4	CPU, %				*22*
	Disk total, KBps				*500*
	Active memory, MB				*350*
	Network total, Mbps				*0*

Notes:

The load generator for this virtual machine was LoadSim2003. The generator was installed within the same virtual machine as the server in order to eliminate network I/O as a variable. LoadSim2003 was configured as seven clients sending and receiving e-mail, posting to public folders and setting appointments in a calendar: all standard Exchange/Outlook features.

It is interesting to note that memory utilization was the highest of the four Application/VM modules. This is typical of how the Microsoft Exchange Information Store operates under load. Disk writes were also comparatively high, also in keeping with how Exchange normally functions.

SQL Server

The following table presents the statistics from the SQL Server virtual machines.

		DP-Entry SC	*DP-Top DC*	*MP-Entry SC*	*MP-Top DC*
VMs	***Parameter***				
SQL1	CPU, %	*27*	*29*	*32*	*28*
	Disk total, KBps	*72*	*79*	*80*	*80*
	Active memory, MB	*40*	*40*	*45*	*45*
	Network total, Mbps	*0*	*0*	*0*	*0*
SQL2	CPU, %		*29*	*32*	*28*
	Disk total, KBps		*79*	*80*	*80*
	Active memory, MB		*40*	*40*	*45*
	Network total, Mbps		*0*	*0*	*0*
SQL3	CPU, %				*28*
	Disk total, KBps				*80*
	Active memory, MB				*45*
	Network total, Mbps				*0*
SQL4	CPU, %				*28*
	Disk total, KBps				*80*
	Active memory, MB				*45*
	Network total, Mbps				*0*
SQL5	CPU, %				*28*
	Disk total, KBps				*80*
	Active memory, MB				*45*
	Network total, Mbps				*0*

Notes:

DTM DB Stress 1.02.18 from SQL Edit generated the loads for this virtual machine. The generator was configured as six clients, half-generating one complex query, the other half a different query. As was done with the Exchange virtual machine, the load generator ran within the same virtual machine as SQL Server. This eliminated contention for network I/O; it is similar in utilization to many SQL Server implementations where there is a SQL Server instance serving a single application installed on the same dedicated server.

Once again, utilization across parameters is very consistent for all of the virtual machines on both platform types (DP and MP).

Hosts Summary

The following table presents the utilization for all parameters, for all virtual machines, on all four platforms.

Parameter	***DP-Entry SC***	***DP-Top DC***	***MP-Entry SC***	***MP-Top DC***
CPU, %	63	59	62	62
Disk total, Kbytes/second	1,570	3,373	3,580	6,709
Active memory, MB	413	540	1,362	1,847

Parameter	*DP-Entry SC*	*DP-Top DC*	*MP-Entry SC*	*MP-Top DC*
Network total, Mbyte/second	110	248	223	354
Number of VMs	4	7	7	17

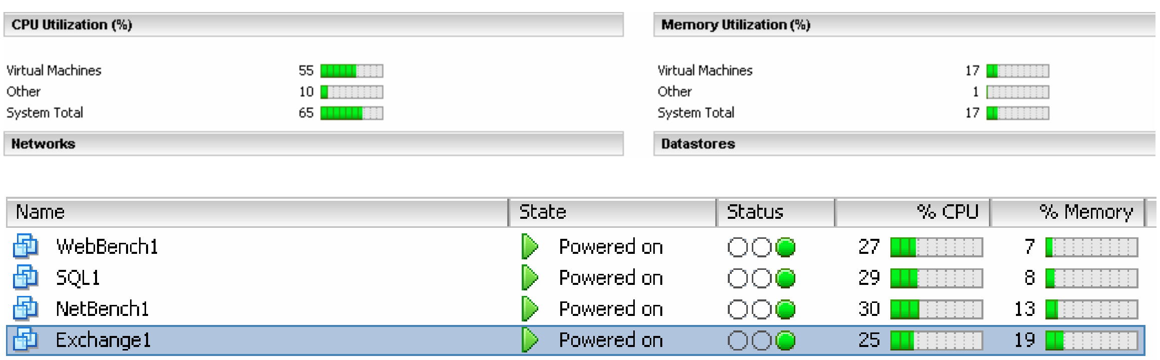
Notes:

As mentioned previously, the data in this table is compiled directly from VMware ESX statistics. The numbers in the previous tables (and in the screen shots below) are snapshots of the data at the time the data was captured. Therefore the numbers presented will vary between representations. The numbers in this table are statistics of all virtual machines running on each platform. The total utilization number includes the utilization overhead of ESX itself, which has been indicated and subtracted from the total utilization levels.

Intel® SC2400JR2 Entry-Level (DP-Entry SC)

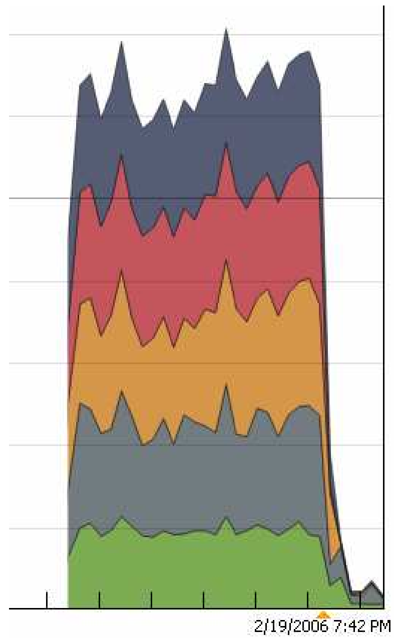
As a result of the VM load calibration, the Intel® SC2400JR2 (DP-Entry SC) unit was able to execute **four** VMs with a total VM-related CPU load of **63 percent. The** graphics below are screenshots from VMware Virtual Center illustrating our findings[6].

Total and Per-VM CPU Utilization for the Intel® SC2400JR2 (DP-Entry SC) Server:



The accuracy of the performance data reported by the VM Virtual Server was independently verified with a Perl script supplied by Intel. The data from the script is depicted on the graph below.

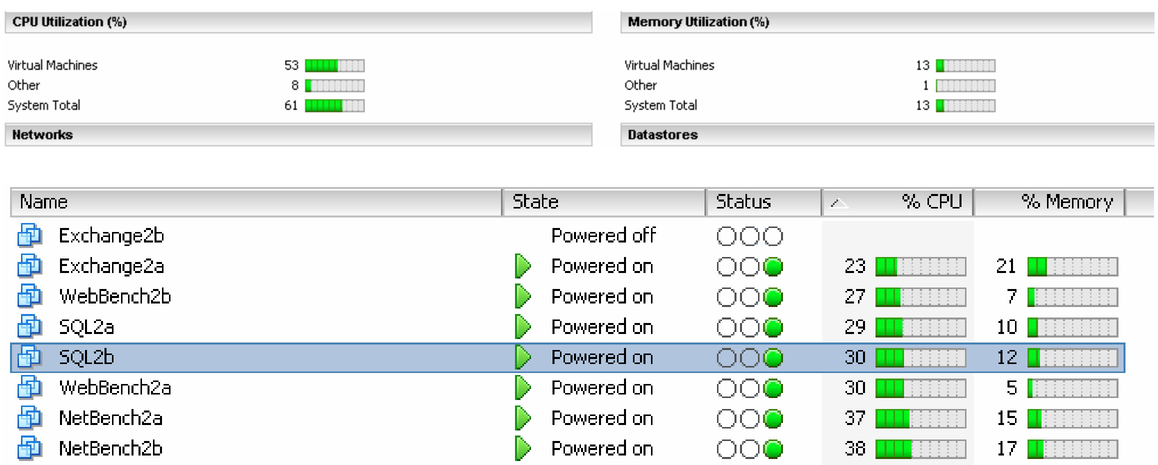
[6] The CPU utilization and other metrics in these graphics are snapshots of the test in progress. The tables in this report are based upon averages of statistical data captured during the entire test run. For this reason the System Total and other metrics in the screen shots may not match those in the tables.



Intel® SC2400JR2 Top-End (DP-Top DC)

The Intel® SC2400JR2 (DP-Top DC) unit was able to execute **seven** VMs with a total VM-related CPU load of **59 percent.** The graphics below are screenshots from VMware Virtual Center illustrating our findings[7].

Total and Per-VM CPU Utilization for the Intel® SC2400JR2 (DP-Top DC) Server:



CPU Utilization (%)	
Virtual Machines	53
Other	8
System Total	61

Memory Utilization (%)	
Virtual Machines	13
Other	1
System Total	13

Networks

Datastores

Name	State	Status	% CPU	% Memory
Exchange2b	Powered off			
Exchange2a	Powered on		23	21
WebBench2b	Powered on		27	7
SQL2a	Powered on		29	10
SQL2b	Powered on		30	12
WebBench2a	Powered on		30	5
NetBench2a	Powered on		37	15
NetBench2b	Powered on		38	17

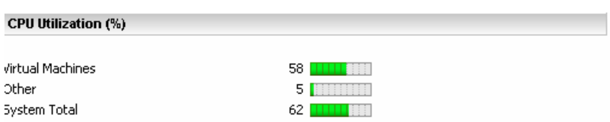
[7] The CPU utilization and other metrics in these graphics are snapshots of the test in progress. The tables in this report are based upon averages of statistical data captured during the entire test run. For this reason the System Total and other metrics in the screen shots may not match those in the tables.

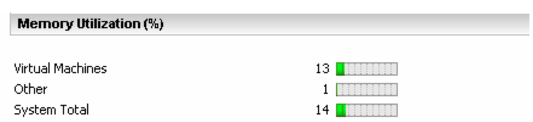
The accuracy of the performance data reported by the VM Virtual Server was independently verified with a Perl script supplied by Intel. The data from the script is depicted on the graph below.

Intel® SR4850HW4 Entry-Level (MP-Entry SC)

The Intel® SR4850HW4 (MP-Entry SC) unit was able to execute **seven** VMs with a total VM-related CPU load of **62 percent. The** graphics below are screenshots from VMware Virtual Center illustrating our findings[8].

Total and Per-VM CPU Utilization for the SR4850HW4 (MP-Entry SC) Server:

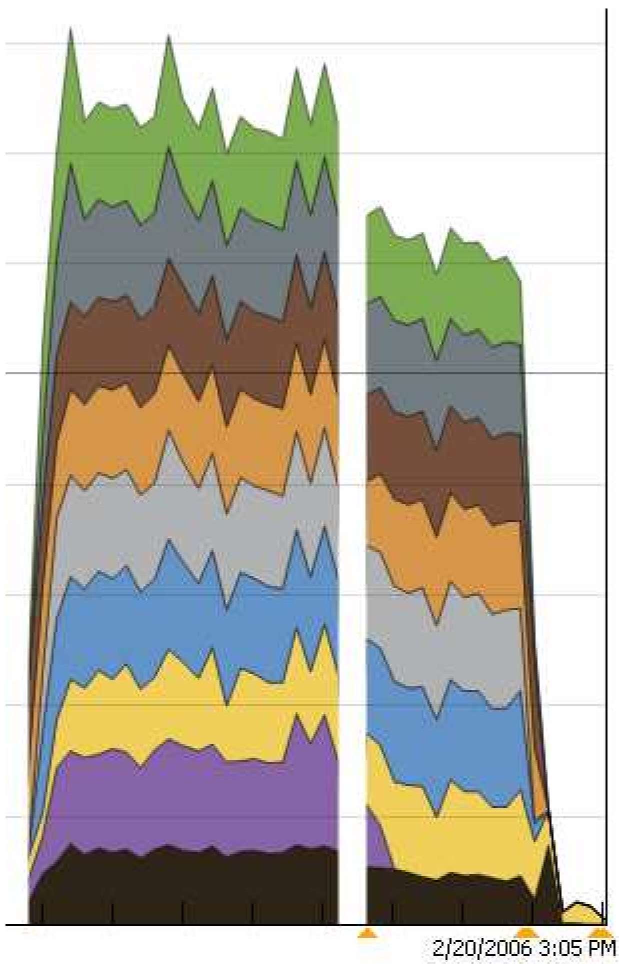




[8] The CPU utilization and other metrics in these graphics are snapshots of the test in progress. The tables in this report are based upon averages of statistical data captured during the entire test run. For this reason the System Total and other metrics in the screen shots may not match those in the tables.

Name	State	Status	% CPU	% Memory
GnuLinux2a	Powered off			
GnuLinux1a	Powered off			
Clone of Exchange2b	Powered on		31	37
Clone of Exchange2a	Powered off			
Clone of SQL2b	Powered on		32	7
Clone of SQL2a	Powered on		32	10
Clone of WebBench2a	Powered on		33	6
Clone of WebBench2b	Powered on		32	7
Clone of NetBench2b	Powered on		36	19
Clone of NetBench2a	Powered on		37	14

The accuracy of the performance data reported by the VM Virtual Server was independently verified with a Perl script supplied by Intel. The data from the script is depicted on the graph below.



Intel® SR4850HW4 Top-End (MP-Top DC)

The Intel® SR4850HW4 (MP-Top DC) unit was able to execute **seventeen** VMs with a total VM-related CPU load of **62 percent. The** graphics below are screenshots from VMware Virtual Center illustrating our findings[9].

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Total and Per-VM CPU Utilization for the Intel® SR4850HW4 (MP-Top DC) Server:

CPU Utilization (%)	
Virtual Machines	58
Other	7
System Total	64

Memory Utilization (%)	
Virtual Machines	22
Other	1
System Total	23

Name	State	Status	% CPU	% Memory
NB1	Powered on		30	17
NB2	Powered on		29	14
NB3	Powered on		30	13
SQL1	Powered on		29	7
SQL2	Powered on		29	12
SQL3	Powered on		29	9
SQL4	Powered on		28	11
WB1	Powered on		29	4
WB2	Powered on		29	6
WB3	Powered on		29	4
WB4	Powered off			
EX1	Powered on		24	26
EX2	Powered on		26	31
EX3	Powered on		23	29
EX4	Powered on		23	19
SQL5	Powered on		29	9
EX5	Powered on		25	17
NB4	Powered on		30	26

The accuracy of the performance data reported by the VM Virtual Server was independently verified with a Perl script supplied by Intel.The data from the script is depicted on the graph below.

[9] The CPU utilization and other metrics in these graphics are snapshots of the test in progress. The tables in this report are based upon averages of statistical data captured during the entire test run. For this reason the System Total and other metrics in the screen shots may not match those in the tables.